PTO/SB/20 (09-07)
Approved for use through 12/31/2008. OMB 0651-0058
U.S. Patent and Trademark Office; U.S DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

REQUEST FOR PARTICIPATION IN THE PATENT PROSECUTION HIGHWAY (PPH) PILOT PROGRAM BETWEEN THE (1) JPO OR (2) UKIPO, AND THE USPTO

Application No.:	10/501,271	First Named Inventor:	Dirk-Jan van Manen
Filing Date:	May 1, 2006	Attorney Docket No.:	14.0202-PCT-US
Title of the Invention:	METHOD OF AND APPARATUS FOR PROCESSING SEISMIC DATA		

THIS REQUEST FOR PARTICIPATION IN THE PPH PILOT PROGRAM MUST BE FAXED TO:
THE OFFICE OF THE COMMISSIONER FOR PATENTS AT 571-273-0125 DIRECTED TO THE ATTENTION OF MAGDALEN GREENLIEF

APPLICANT HEREBY REQUESTS PARTICIPATION IN THE PATENT PROSECUTION HIGHWAY (PPH) PILOT PROGRAM AND PETITIONS TO MAKE THE ABOVE-IDENTIFIED APPLICATION SPECIAL UNDER THE PPH PILOT PROGRAM.

The above-identified application validly claims priority under 35 U.S.C. 119(a) and 37 CFR 1.55 to one or more corresponding JPO application(s) or UKIPO application(s).

The ☐ JPO ☒ UKIPO application number(s) is/are: 0200560.1

The filing date of the ☐ JPO ☒ UKIPO application(s) is/are: 11 Jan. 2002

I. List of Required Documents:

a. **A copy of all JPO office actions (<u>excluding</u> "Decision to Grant a Patent"*) in the above-identified JPO application(s), <u>or</u> a copy of all UKIPO office actions in the above-identified UKIPO application(s).**

☒ Is attached.

☐ Is available via Dossier Access System Applicant hereby requests that the USPTO obtain these documents via the Dossier Access System.

*It is <u>not</u> necessary to submit a copy of the "Decision to Grant a Patent" and an English translation thereof.

b. **A copy of all claims which were determined to be patentable by the JPO in the above-identified JPO application(s), <u>or</u> a copy of all claims which were determined to be patentable by the UKIPO in the above-identified UKIPO application(s).**

☒ Is attached.

☐ Is available via Dossier Access System. Applicant hereby requests that the USPTO obtain these documents via the Dossier Access System.

c. **English translations (where applicable) of the documents in a. and b. above along with a statement that the English translations are accurate are attached.**

Information disclosure statement listing the documents cited in the JPO office actions <u>or</u> UKIPO office actions is attached.

Copies of all documents are attached except for U.S. patents or U.S. patent application publications.

REQUEST FOR PARTICIPATION IN THE PATENT PROSECUTION HIGHWAY (PPH) PILOT PROGRAM BETWEEN THE (1) JPO OR (2) UKIPO, AND THE USPTO

(continued)

Application No.:	10/501,271	First Named Inventor:	Dirk-Jan van Manen

II. Claims Correspondence Table:

Claims in US Application	Patentable Claims in JP/UKIPO Application	Explanation regarding the correspondence
1-7 10-15 17 19-20	1-7 8-13 14 15-16	The corresponding claims are substantively identical except the multiple-dependent claim format in the GB patent.

III. All the claims in the US application sufficiently correspond to the patentable/allowable claims in the JPO or UKIPO application.

IV. Payment of Fees:

The Commissioner is hereby authorized to charge the petition fee under 37 CFR 1.17(h) as required by 37 CFR 1.102(d) to

☒ **Deposit Account No.** 50-1720.

☐ **Credit Card. Credit Card Payment Form (PTO-2038) is attached.**

Signature	/liangang mark ye/	Date	11/09/2007
Name (Print/Typed)	Liangang (Mark) Ye	Registration Number	48,276

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Dirk-Jan van Manen *et al.*	§	Group Art Unit: 2857
	§	
Serial Number: 10/501,271	§	Examiner: Unknown
	§	
Confirmation Number: 5653	§	Atty Dkt No.: 14.0202-PCT-US
	§	
Filing Date: May 1, 2006	§	
	§	
Entitled: METHOD OF AND APPARATUS FOR PROCESSING SEISMIC DATA	§ §	

Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

Index of documents

accompanied a request for participation in the Patent Prosecution Highway (PPH) Pilot Program between the UKIPO and the USPTO.

1. The request (2 pages)
2. **This index (1 page)**
3. Preliminary amendment (4 pages)
4. Search report from UK IPO, 4 October, 2002 (4 pages, including a cover)
5. Publication notice from UK IPO, 17 June, 2003 (3 pages, including a cover)
6. Examination report from UK IPO, 20 January, 2005 (3 pages, including a cover)
7. Notification of Grant, 15 March, 2005, (3 pages, including a cover)
8. UK patent, GB 2 384 068 B (29 pages, including a cover)
9. Non-US references cited by GB search report, GB2333364A (Geco), EP0515188A2(Halliburton), and WO9729390 (PGS). These references were disclosed in an IDS filed on 1/10/2007, among other references. (65 pages, including covers)
10. Two IDS were submitted in this case, a first one on 5/1/2006 together with the national phase entrance; a second one on 1/10/2007. (copy not included)

Remote User

[redacted]

14.0202-GB, 20050415, Patent 2384068.pdf
10/26/07 05:04 PM (29)

(12) UK Patent (19) GB (11) 2 384 068 (13) B

(45) Date of publication: 13.04.2005

(54) Title of the invention: A method of and apparatus for processing seismic data

(51) Int Cl[7]: G06F 19/00, G01V 1/28 1/38

(21) Application No: 0200560.1

(22) Date of Filing: 11.01.2002

(43) Date A Publication: 16.07.2003

(52) UK CL (Edition X):
G4A AUA
G1G GEL G3P

(56) Documents Cited:
GB 2333364 A
WO 1997/029390 A1
EP 0515188 A2
US 5793702 A

(58) Field of Search:
As for published application 2384068 A *viz:*
INT CL[7] G06F
Other: ONLINE: EPODOC, WPI, PAJ, INTERNET
updated as appropriate

Additional Fields
INT CL[7] G01V

(72) Inventor(s):
Johan Olof Anders Robertsson
Aslaug Strømmen Melbø
Dirk-Jan van Manen

(73) Proprietor(s):
WesternGeco Limited
(Incorporated in the United Kingdom)
Schlumberger House, Buckingham Gate,
Gatwick Airport, GATWICK, West Sussex,
RH6 0NZ, United Kingdom

(74) Agent and/or Address for Service:
Marks & Clerk
4220 Nash Court,
Oxford Business Park South, OXFORD,
OX4 2RU, United Kingdom

2384068

FIG 1

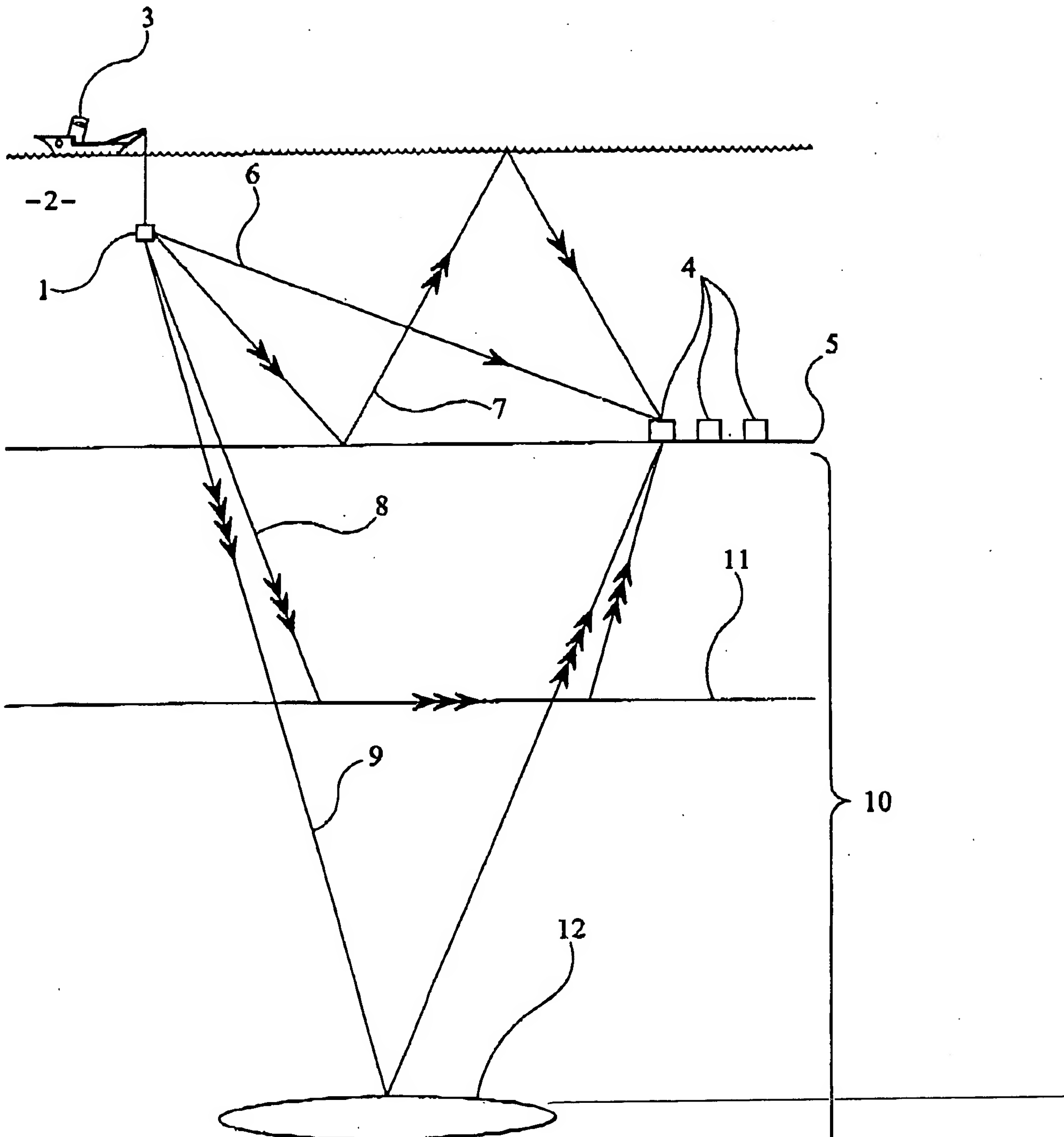
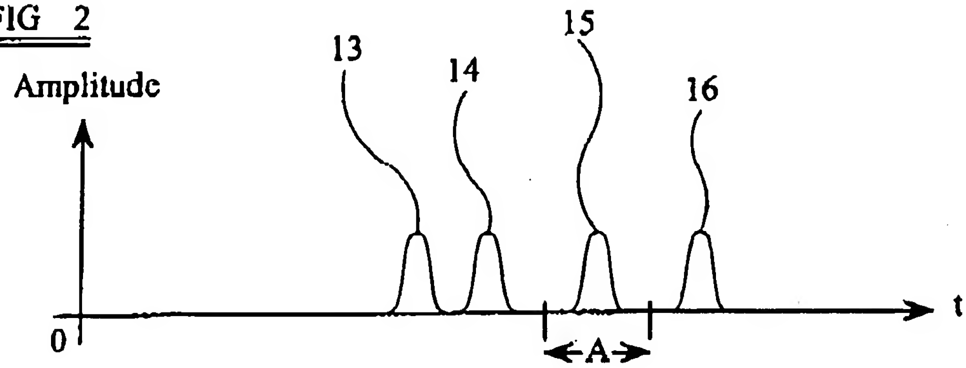


FIG 2



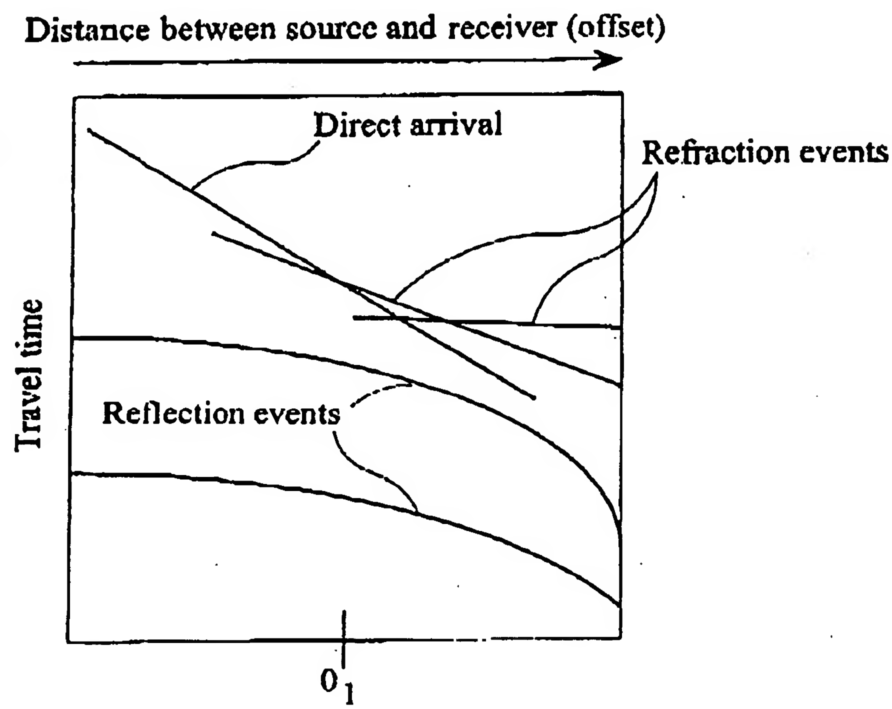


FIG 3

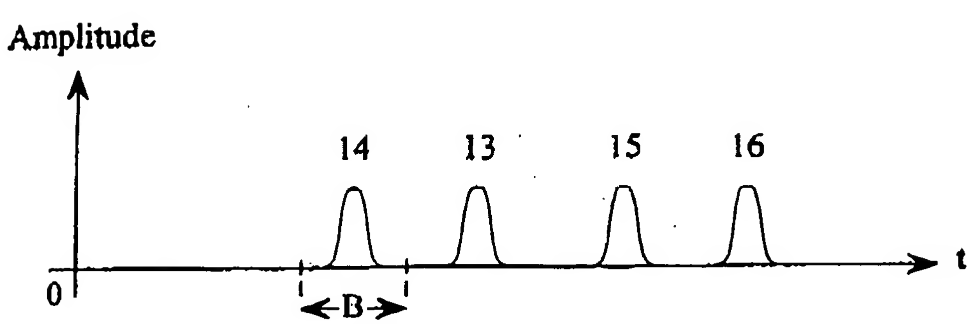


FIG 4

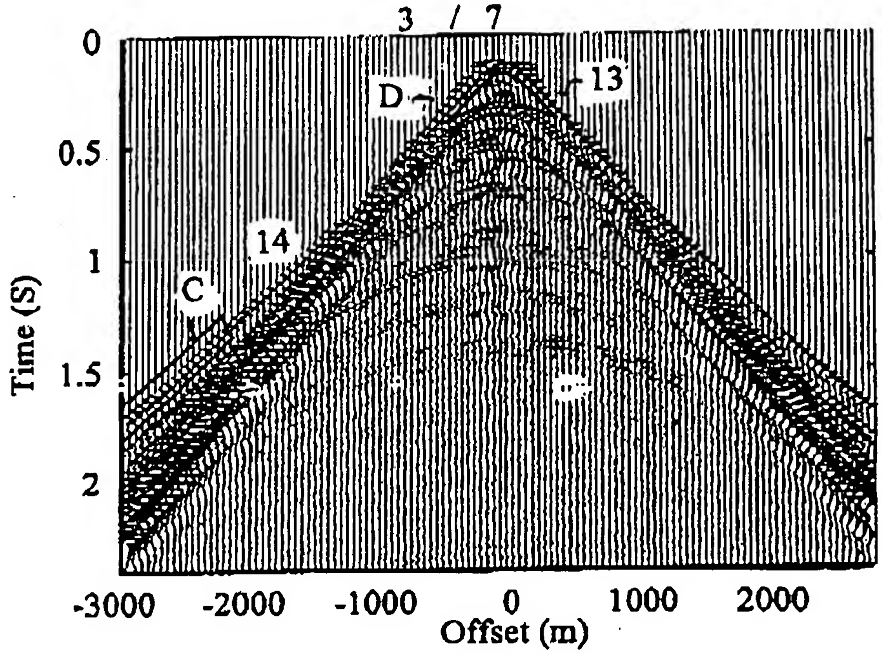


FIG 5

Raw pressure data with two posible minimization windows; one containing the critical refraction event (c), and one containing the primary refections (D).

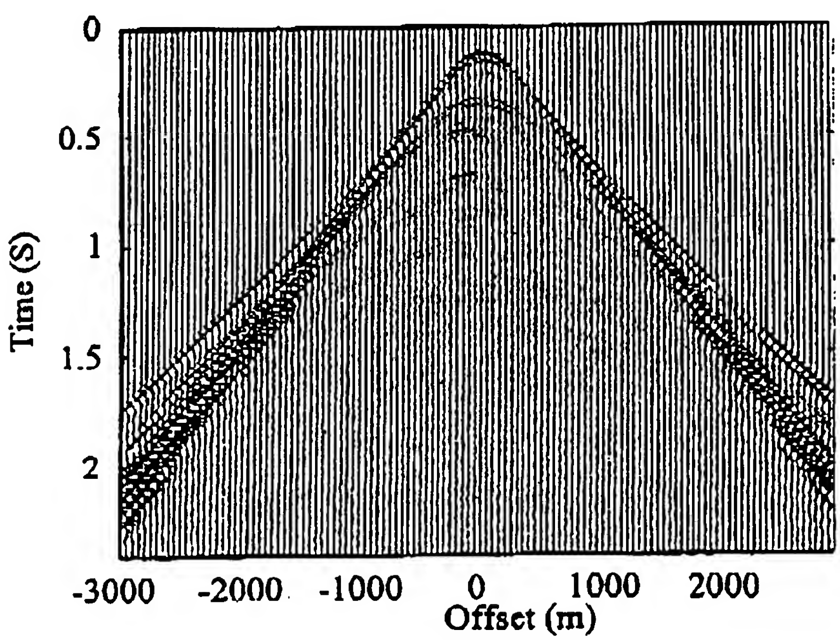


FIG 6

Upgoing pressure when no calibration filter is applied.

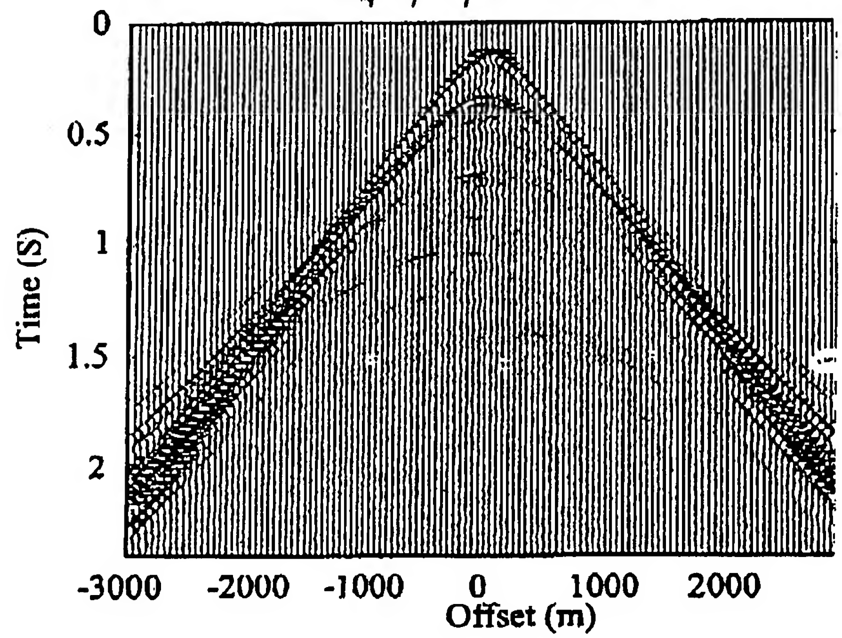


FIG 7

Downgoing pressure when no calibration filter is applied.

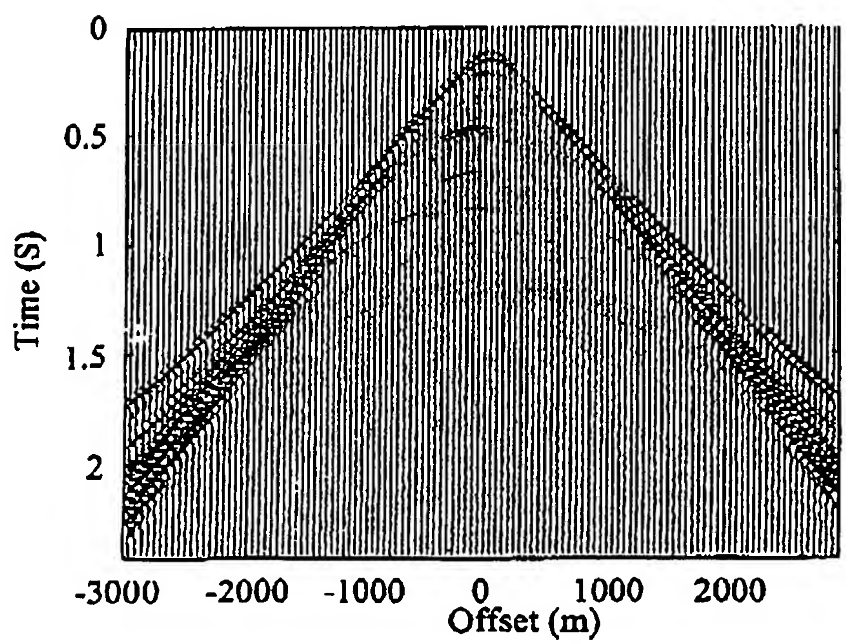


FIG 8

Upgoing pressure when no calibration filter is applied.

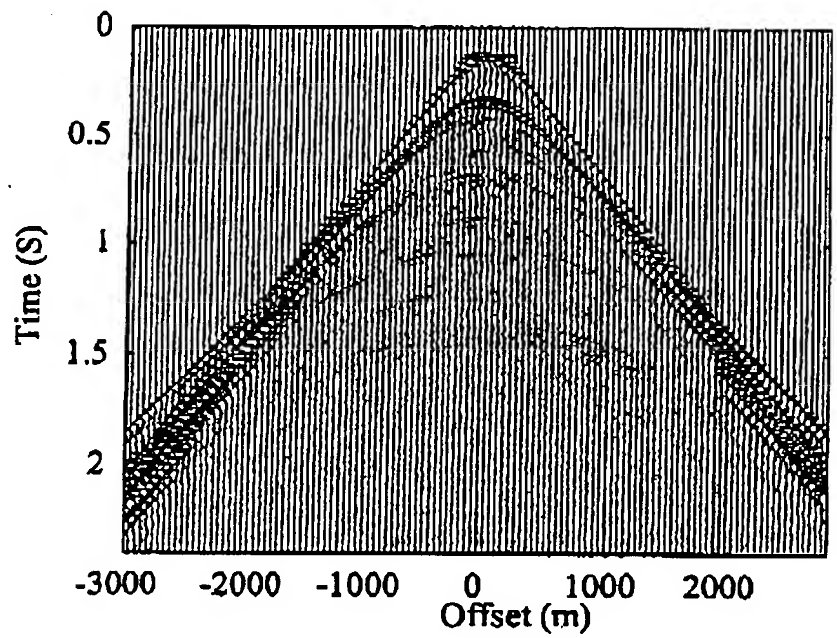


FIG 9

Downgoing pressure when no calibration filter is applied.

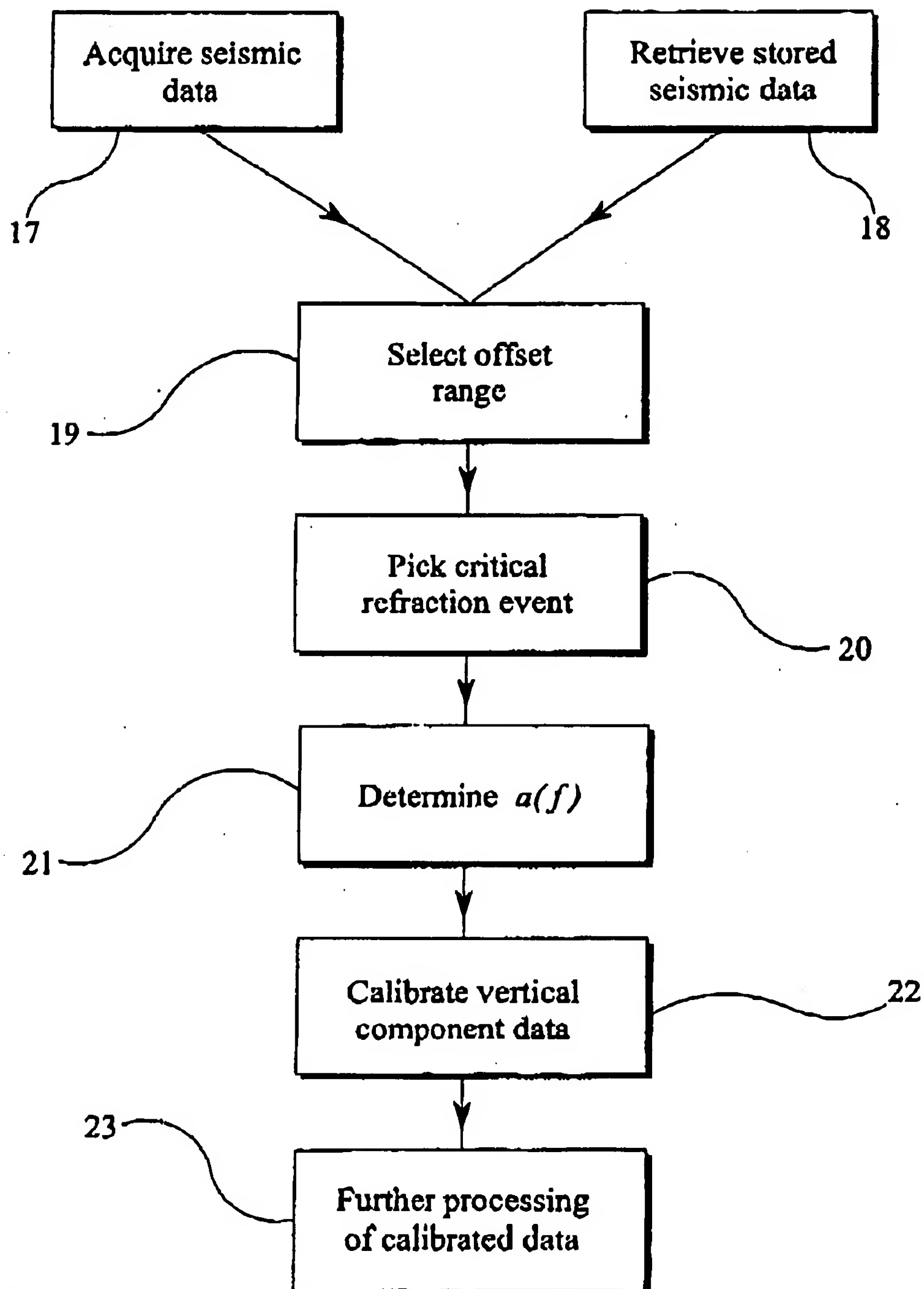
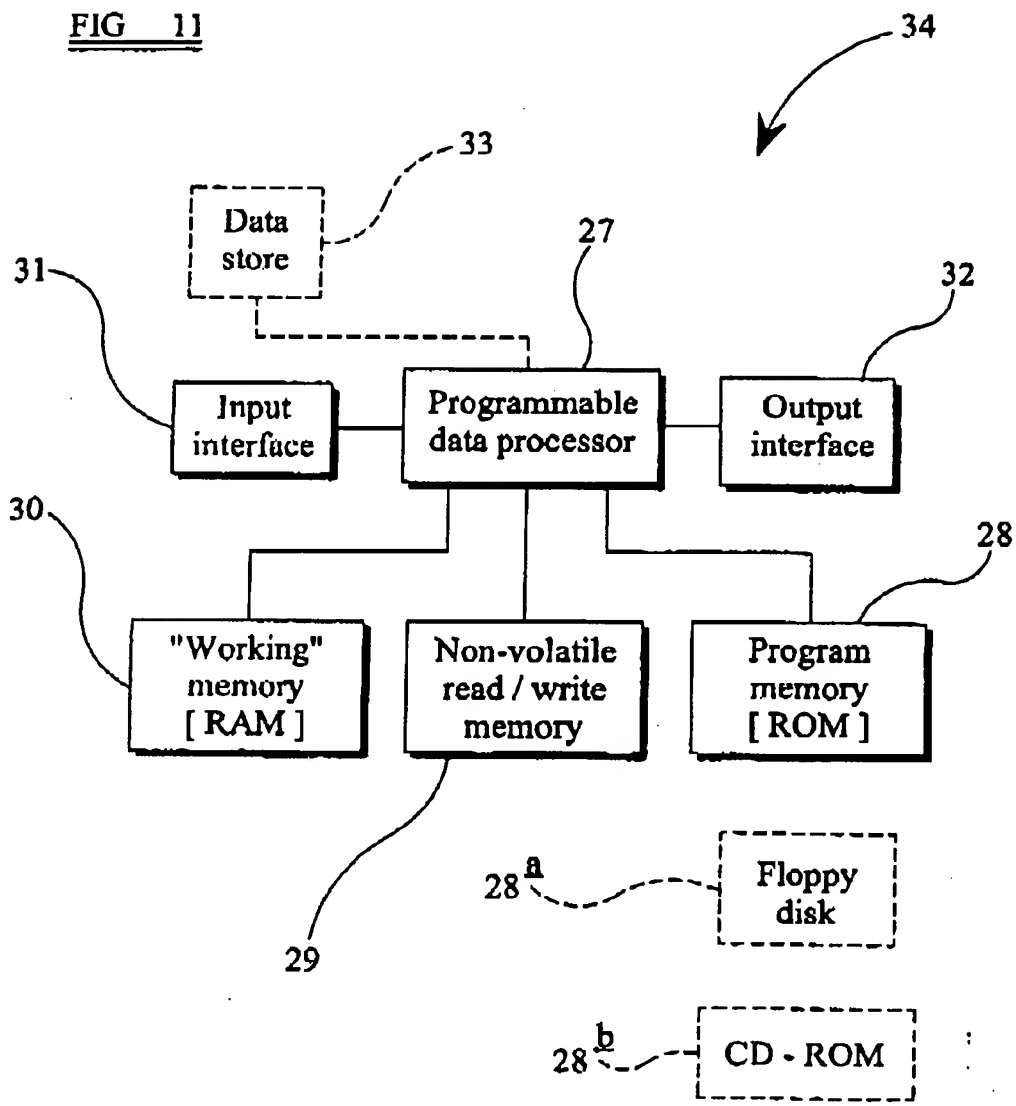

Acquire seismic data
Retrieve stored seismic data
17
18
Select offset range
19
Pick critical refraction event
20
Determine a(f)
21
Calibrate vertical component data
22
23
Further processing of calibrated data

FIG 10

FIG 11


34
33
Data store
27
31
32
Input interface
Programmable data processor
Output interface
30
28
"Working" memory [RAM]
Non-volatile read / write memory
Program memory [ROM]
28a
Floppy disk
29
28b
CD - ROM

2384068

A method of and apparatus for processing seismic data

The present invention relates to a method of processing multi-component seismic data. It particularly relates to a method of processing seismic data to determine a calibration filter that calibrates one component of the seismic data relative to another component of the seismic data. The invention further relates to an apparatus for processing seismic data.

Figure 1 is a schematic view of a seismic surveying arrangement. In this figure the surveying arrangement is a marine surveying arrangement in which seismic energy is emitted by a seismic source 1 that is suspended within a water column 2 from a towing vessel 3. When the seismic source 1 is actuated seismic energy is emitted downwards and is detected by an array of seismic receivers 4 disposed on the seafloor 5. (As used herein the term "seabed" denotes the earth's interior, and the term "seafloor" denotes the surface of the seabed.)

Many seismic surveys now use multi-component receivers that record two or more components of the seismic energy incident on the receiver. For example a 3-component (3-C) seismic receiver contains three orthogonal geophones and so can record the x-, y- and z-components of the particle motion at the receiver (the particle motion may be the particle displacement, particle velocity or particle acceleration or even, in principle, a higher derivative of the particle displacement). In a marine seismic survey a 4-component (4-C) seismic receiver can alternatively be used. A 4-C receiver contains a pressure sensor such as a hydrophone in addition to three orthogonal geophones and so can record the pressure of the water column (which is a scalar quantity) in addition to the x-, y- and z-components of the particle motion.

Many different paths exist by which seismic energy may travel from the source 1 to a receiver 4 in the seismic surveying arrangement of Figure 1. A number of paths are indicated schematically in Figure 1.

The path 6 shown in Figure 1 is known as the "direct path". Seismic energy that travels along the direct path 6 travels from the source 1 to a receiver 4 essentially in a straight line without undergoing reflection at any interface.

Path 7 in Figure 1 is an example of a "water layer multiple path". Seismic energy that follows a water layer multiple path propagates wholly within the water column 2, but undergoes one or more reflections at the surface of the water column and/or the seafloor 5 so that the seismic energy passes through the water column more than once. The water layer multiple path 7 shown in Figure 1 involves one reflection at the seafloor 5 and one reflection at the surface of the water column, but many other water layer multiple paths exist.

The path 8 in Figure 1 is an example of a "critical refraction path". Seismic energy that follows the path 8 propagates downwards to the seafloor 5, and penetrates into the earth's interior 10 (ie into the seabed). The seismic energy continues propagating downwardly, until it reaches a boundary 11 between two layers of the earth that have different acoustic impedance. The seismic energy undergoes critical refraction, propagates along the boundary 11, before eventually being refracted upwards towards the receiver 4. Critical refraction may also occur at the water-seabed interface, and downwardly propagating seismic energy that is refracted in this way will propagate along the water-seabed interface and will then propagate upwardly into the water column.

The path 9 shown in Figure 1 is known as a "primary reflection path". Seismic energy that follows the primary reflection path 9 propagates downwards through the water column, is refracted at the seafloor 5, and propagates downwardly through the earth's interior. The seismic energy is refracted at the boundary 11, but is not critically refracted and so continues to propagate downwardly into the earth. It eventually undergoes reflection at a geological structure 12 that acts as a partial reflector of seismic energy, and the reflected seismic energy is, after further refraction as it passes upwardly through the boundary 11, incident on the receiver 4. The general intent of a seismic

survey is to make use of the seismic energy that follows the primary reflection path in order to obtain information about the interior structure of the earth.

Seismic energy acquired at a receiver may contain upwardly and/or downwardly propagating seismic energy depending on the location of the receiver and on the event. For example seismic energy that travels along the critical refraction path 8 shown in Figure 1 will, when it is incident (travelling upwardly) on the water-seabed interface, be partly transmitted into the water column and partially reflected back into the seabed 10. Thus, a critical refraction event will consist purely of upwardly propagating seismic energy above the seafloor 5, but will contain both upwardly and downwardly propagating seismic energy below the seafloor 5. As another example, seismic energy that travels along the direct path 6 shown in Figure 1 will, when incident on the water-seabed interface 5, be partially transmitted into the seabed and partially reflected back into the water column. Hence, the direct event will contain both upwardly and downwardly propagating seismic energy above the seafloor, but will contain only downwardly propagating seismic energy below the seafloor. It is therefore often of interest to decompose the seismic data acquired at the receiver 4 into an up-going constituent and a down-going constituent, above or below the seafloor 5. For example, in a 4-C seismic survey it may be of interest to decompose the pressure and the vertical particle velocity recorded at the receiver into their up-going and down-going constituents above the seafloor. Various filters that enable decomposition of seismic data into up-going and down-going constituents have been proposed. One example can be found in K.M. Schalkwijk et al, "Application of Two-Step Decomposition to Multi-Component Ocean-Bottom Data: Theory and Case Study", J. Seism. Expl. Vol. 8 pp261-278 (1999), and states that the down-going and up-going constituents of the pressure just above the seafloor may be expressed as follows:

$$P^{-}(f,k)=\frac{1}{2}P(f,k)-\frac{\rho}{2q(f,k)}Z(f,k),$$
$$P^{+}(f,k)=\frac{1}{2}P(f,k)+\frac{\rho}{2q(f,K)}Z(f,k), \qquad (1)$$

where P is the pressure acquired at the receiver, P^- is the up-going constituent of the pressure above the seafloor, P^+ is the down-going constituent of the pressure above the seafloor, f is the frequency, k is the horizontal wavenumber, Z is the vertical particle velocity component acquired at the receiver, ρ is the density of the water, and q is the vertical slowness in the water layer.

As can be seen, the expressions in equation (1) require two of the components of seismic data recorded at the receiver to be combined. These filters are an example where it is necessary to combine two components of the acquired seismic data. It may also be necessary to combine two or more components of the acquired seismic data in order to decompose the acquired seismic data into p-wave and s-wave (pressure-wave and shear-wave) components, or to remove water level multiple events from the seismic data.

One problem in combining different components of the seismic data acquired at a receiver is that the different components of the seismic data may not be correctly calibrated against one another. This is particularly the case where the two components that are being combined are, as in equation (1), the pressure and the vertical particle velocity. There are usually differences in coupling or impulse response between the hydrophone used to acquire the pressure and the geophone used to acquire the vertical particle velocity. It is necessary to calibrate the data for these differences before the pressure and vertical particle velocity can be combined. This may be done by developing a calibration filter that compensates for the differences in coupling and impulse response between the hydrophone and the vertical geophone.

Schalkwijk et al, and others, have suggested that the calibration problem can be addressed by assuming that one component of the seismic data has been correctly recorded, and calibrating the other component of the seismic data against the component that is assumed to be correctly recorded. In general, it is assumed that the hydrophone is well coupled, so that the pressure recording is taken to be correct. The vertical component of the particle velocity is then calibrated against the pressure to compensate for coupling and impulse response differences between the hydrophone and the vertical

geophone. Schalkwijk et al therefore proposed that equation (1) above should be modified by applying a calibration filter to the vertical particle velocity. They proposed that the equation given above for the down-going constituent of the pressure above the seafloor should be modified to read as follows:

$$P^{+}(f,k)=\frac{1}{2}P(f,k)+a(f)\frac{p}{2q(f,k)}Z(f,k). \qquad (2)$$

In equation (2) *a(f)* represents a frequency-dependent calibration filter. The remaining terms in equation (2) have the same meaning as in equation (1).

The method proposed by Schalkwijk et al for determining the calibration filter *a(f)* is to minimise the energy of the down-going pressure constituent above the seafloor for a portion of the seismic data that contains only primary reflections. Seismic energy travelling along a primary reflection path is propagating upwardly just above the seafloor at the receiver position, so that the down-going constituent of the pressure just above the seafloor should be zero for data that contains only primary reflections. Schalkwijk proposed that the calibration filter that minimises the energy of the down-going pressure in a window containing only primary reflection events can be found using a least squares method. Once the calibration filter *a(f)* has been determined in this way, it is applied to the entire data set for the vertical particle velocity.

The existence of various paths of seismic energy from the source to the receiver means that the data acquired at the receiver in a real seismic survey will contain events corresponding to more than one possible path. These events will occur at different times after the actuation of the seismic source 1, as different paths of seismic energy have different associated travel times. Figure 2 is a schematic illustration of seismic data that might be acquired at the receiver 4, and it shows the amplitude of seismic energy recorded at the receiver 4 as a function of the time since the actuation of the source 1. Figure 2 illustrates a direct event 13, corresponding to the direct path 6, a critical refraction event 14 corresponding to the critical refraction path 8, a primary event 15 corresponding to the primary reflection path 9, and a water layer multiple

event 16 corresponding to the water layer multiple path 7. (In practice, data acquired at a receiver will contain a plurality of primary reflection events from different geological structures, a plurality of critical refraction events, and a plurality of water level multiple events arising from different water level multiple paths. Only one event of each type is shown in Figure 2 for simplicity of explanation.) In order to apply the method of Schalkwijk et al to determine the calibration filter, data in a time window that contains only the primary event 15, such as the time window A shown in Figure 2, must be selected.

The present invention provides a method of processing multi-component seismic data obtained from seismic signals propagating in a medium, the method comprising the steps of: selecting a first portion of the seismic data containing only events arising from critical refraction of seismic energy; and determining a first calibration filter from the first portion of the seismic data, the first calibration filter being to calibrate a first component of the seismic data relative to a second component of the seismic data.

The method proposed by Schalkwijk et al has the disadvantage that the time window containing only primary reflection events has to be picked manually. The primary reflection events are not the first events acquired at the receiver following actuation of the source, and so cannot be picked automatically. A further disadvantage is that in some cases, for example if the seismic source has a long signature, it may be hard to distinguish between the direct arrival and the primary reflection events, so that it may be difficult to isolate the correct events. The direct event contains downwardly propagating seismic energy so that use of a time window that inadvertently included the direct event would not give correct results for the calibration filter, since the method for determining the calibration filter assumes that the selected data contains only up-going energy. A further problem with the method of Schalkwijk et al is that in shallow water the water layer multiple events may arrive at substantially the same time as the primary reflection events, and this again makes it difficult to pick a time window that includes only the primary reflection events.

The present invention makes use of the fact that the critical refraction events consist only of up-going seismic energy just above the seafloor. Thus, selecting a time window that contains only one or more critical refraction events makes it possible to determine the calibration filter $a(t)$ by the technique of minimising the energy of the down-going pressure just above the seafloor in that time window.

The method of the invention is particularly advantageous when applied to long offset data. As is shown in Figure 3, as the offset (that is, the horizontal distance between the source and the receiver) increases, the arrival time of the first critical refraction event increases more slowly than does the arrival time of the direct event. For offsets greater than O_1 the first arrival at the receiver is not the direct event, but is the critical refraction event. That is, at long offsets the critical refraction event 14 in Figure 2 (two critical refraction events are shown in Figure 3) will arrive before the direct event 13 and will be the first arrival at the receiver. When the invention is applied to data having a source-receiver offset sufficiently large for the first event acquired at the receiver to be a critical refraction event, it is possible to use a time window that covers only the first event acquired at the receiver – and this makes it possible to use an automatic picking method to determine the time window. If several critical refraction events arrive at the receiver before the direct event, as for far offsets in Figure 3 where two critical refraction events arrive before the direct event arrives, then all these critical refraction events may be included in the time window.

Figure 4 is a schematic illustration that corresponds to Figure 2, but illustrates the arrival times of the events at an offset that is sufficiently large such that the first arrival is a critical refraction event. In this case, the invention may be applied by selecting the time window B which includes the critical refraction event only, and minimising the energy of the down-going pressure above the seafloor in this time window.

A further advantage of the invention is that the method may be applied to seismic data acquired in shallow waters. Although water layer multiple events in seismic data acquired in shallow water may coincide with primary reflection events, they do not coincide with critical refraction events. Choosing a time window that includes only the

critical refraction event therefore ensures that the time window cannot contain water layer multiple events. The invention also overcomes the problems that arise when a seismic source having a long source signature is used.

A preferred embodiment of the invention comprises the further steps of selecting a second portion of the seismic data containing only events arising from primary reflection of seismic energy and determining a second calibration filter from the second portion of the seismic data, the second calibration filter being to calibrate the first component of the seismic data relative to the second component of the seismic data. It may comprise the further step of determining a wavenumber-dependent calibration filter from the first calibration filter and the second calibration filter.

A further problem related to the method proposed by Schalkwijk et al is that the correct calibration filter $a(f)$ may well be dependent on the wavenumber as well as on the frequency. The calibration filter proposed by Schalkwijk, however, is dependent only on frequency and, furthermore, is derived purely from seismic data at low wavenumbers. In an embodiment of the present invention, the filter obtained from the critical refraction events is combined with a filter obtained from primary reflection events, and a wavenumber-dependent filter is obtained from the two individual filters. The wavenumber-dependent filter may be obtained by, for example, interpolation between the filter derived from the critical refraction events and the filter derived from the primary reflection events.

A second aspect of the invention provides a method of processing multi-component seismic data obtained from seismic signals propagating in a medium, the method comprising the steps of: selecting a first portion of the seismic data in which the first arrival contains only upwardly propagating seismic energy above the seafloor; and determining a first calibration filter from the first portion of the seismic data, the first calibration filter being to calibrate a first component of the seismic data relative to a second component of the seismic data.

The invention may be applied to any event that is the first arrival and that contains only upgoing energy above the seafloor. For example, at far offsets the first arrival may be an event which is not a critical refraction event but which nevertheless contains only upgoing energy above the seafloor - such as, for example, a wave that was trapped in a thin subsurface layer of the seabed - and the invention may be applied to such events.

The invention may further comprise the step of calibrating the first component of the seismic data using the first calibration filter or using the wavenumber-dependent calibration filter.

A third aspect of the present invention provides a method of seismic surveying comprising the steps of: actuating a source of seismic energy; acquiring seismic data at a receiver spatially separated from the source; and processing the seismic data by a method as defined above.

A fourth aspect of the present invention provides an apparatus for processing multi-component seismic data to determine a calibration filter to calibrate a first component of the seismic data relative to a second component of the seismic data, the apparatus comprising: means for selecting a first portion of the seismic data containing only events arising from critical refraction of seismic energy; and means for determining a first calibration filter from the first portion of the seismic data. The apparatus may comprise a programmable data processor.

A fifth aspect of the invention provides an apparatus for processing multi-component seismic data to determine a calibration filter to calibrate a first component of the seismic data relative to a second component of the seismic data, the apparatus comprising: means for selecting a first portion of the seismic data in which the first arrival contains only upwardly propagating seismic energy above the seafloor; and means for determining a first calibration filter from the first portion of the seismic data.

The apparatus may comprise a programmable data processor.

An sixth aspect of the present invention provides a storage medium containing a program for an apparatus as defined above.

Preferred embodiments of the present invention will now be described by way of illustrative example with reference to the accompanying figures in which:

Figure 1 is a schematic illustration of a seismic survey;

Figure 2 is a schematic illustration of the seismic energy acquired at a receiver in the seismic survey of Figure 1;

Figure 3 is a schematic illustration of the variation of arrival time of seismic energy as a function of offset between the source and the receiver;

Figure 4 is a schematic illustration of the seismic energy acquired in the seismic survey of Figure 1 at long offsets, illustrating a method of the present invention;

Figure 5 is a schematic illustration of pressure recorded at a receiver in the seismic surveying arrangement of Figure 1;

Figures 6 and 7 illustrate the up-going and down-going constituents of pressure above the seafloor obtained from the pressure data shown in Figure 5 according to a prior art approach;

Figures 8 and 9 illustrate the up-going and down-going pressure constituents above the seafloor obtained from the pressure data of Figure 5 according to a method of the present invention;

Figure 10 is a schematic block flow diagram of a method of the present invention; and

Figure 11 is a block schematic diagram of an apparatus according to the present invention.

Figure 5 illustrates typical pressure data recorded at a 4-C receiver in a seismic survey such as the survey shown in Figure 1. The x-axis in Figure 5 indicates the offset between the source and the receiver, and the y-axis indicates the time after actuation of the seismic source. The data are common receiver data and were acquired using a single receiver and a linear array of sources deployed with a spacing of 50m between each pair of adjacent sources. Each trace represents the pressure acquired at the receiver when one source is actuated, with the amplitude of the acquired pressure being in the x-direction.

It should be noted that different receivers in an array may well have different coupling, different instruments responses etc, even if all the receivers are nominally identical to one another. The calibration filter required for data acquired at one receiver in a receiver array is therefore likely to be different from the calibration filter required for data acquired at another receiver in the array. The invention is therefore preferably applied to common receiver gathers and a separate calibration filter is determined for each common receiver gather

The pressure data shown in Figure 5 contains a large number of seismic events. The event labelled 13 is the direct wave, and it will be seen that this is the first arrival for offsets having a magnitude of up to approximately 1,000m. The event labelled 14 is a critical refraction event, and it will be seen that this is the first arrival for offsets having a magnitude significantly greater than 1,000m.

Figures 6 and 7 illustrate the up-going constituent above the seafloor (Figure 6) and the down-going constituent above the seafloor (Figure 7) of the pressure shown in Figure 5 obtained using the filters given in equation (1) above. That is, the up-going and down-going constituent shown in Figures 6 and 7 were obtained on the assumption that the pressure data and the vertical particle velocity data (not illustrated) were correctly calibrated to one another Inspection of Figures 6 and 7 shows that this assumption is incorrect. In particular, the critical refraction event 14 contains only up-going energy above the seafloor and so should appear only in the up-going pressure constituent and

should not appear in the down-going pressure constituent. It will, however, be seen that the up-going critical refraction event has leaked through into the down-going pressure constituent shown in Figure 7, and this indicates that the calibration is unsatisfactory.

According to the present invention, a calibration filter is determined from the critical refraction event 14. As noted above, for traces acquired at a source-receiver offset having a magnitude well above 1000m, the critical refraction event is the first event acquired at the receiver, and is well-separated from the subsequent event. It is therefore possible for such traces to define a time-offset window that includes only the first critical refraction event, and so includes only up-going energy.

One suitable time-offset window of data is illustrated in Figure 5, as the region C. It will be seen that this region includes traces acquired at an offset of between –3000m to approximately –2100m. For each trace in this offset range the region C defines a time window that includes only the first refraction event (which is the first arrival in each of the selected traces). It will be noted that the centre point of the time window for a particular trace is not constant between traces but increases with increasing magnitude of offset.

The calibration filter for the vertical velocity component is then calculated on the assumption that the energy in the selected portion C of the data should contain only up-going energy. The calibration filter may be determined in any suitable way. In particular, the calibration filter $a(f)$ may be determined by finding the calibration filter that minimises the energy of the down-going pressure constituent using a least squares process, as in the method of Schalkwijk et al. Once the appropriate calibration filter $a(f)$ has been determined, revised filters for determining the up-going and down-going constituents of the pressure above the seafloor can be determined using equation (2), or in general the filter $a(f)$ may be applied to the entire gather of the vertical component data, and the calibrated vertical component data can then be used as an input to any process requiring a combination of the vertical component with any other seismic components.

Another suitable portion of data exists in the corresponding region for positive offsets in the range 2100 to 3000m. One possible implementation of the method would be to use both these regions, by defining a second region, analogous to the region C in Figure 5, for offsets in the range +2100m to +3000m and determining a second calibration filter The two filters determined from the two windows may then be averaged. This will however not be possible for all data sets since a receiver gather does not necessarily have the same amount of positive and negative offsets, and hence a region with a clearly separated critical refraction event may be present only for either positive or negative offsets.

Figures 8 and 9 illustrate the results of decomposing the pressure data of Figure 5 into its up-going and down-going constituents above the seafloor using filters of the type given in equation (2) above, and with the calibration filter $a(f)$ determined from the seismic data in the region C of Figure 5. It will be noted that the critical refraction event 14 appears predominantly in the up-going pressure constituent of Figure 8, and is almost completely absent from the down-going pressure constituent of Figure 9. This illustrates that the decomposition of Figures 8 and 9 is significantly more accurate than the decomposition of Figures 6 and 7, since the critical refraction event is expected to occur only in the up-going pressure constituent.

It will also be noted that the primary reflection event is stronger in the up-going pressure constituent of Figure 8 than in the up-going pressure constituent of Figure 6. This suggests that the calibration filter found from the critical refraction event at long offsets is also applicable at low offsets.

Figure 10 is a block flow diagram illustrating one embodiment of the method of the present invention.

Initially, at step 17, seismic data is acquired. This may be, for example, acquired in a survey of the type shown in Figure 1.

The invention may alternatively be applied to pre-existing seismic data. Step 17 may therefore be replaced by the alternative step 18 of retrieving pre-existing seismic data from storage.

At step 19 a suitable offset range is selected. In the example described above with reference to Figure 5, step 19 consists of selecting the offset range from 3,000m to 2100m.

At step 20, the first arrival of seismic energy for each trace in the selected offset range is determined (this may be thought of a selecting a time window for each trace, and so defining an offset-time window). Assuming that the offset range has been selected correctly in step 19, the first arrival in each trace in the selected offset range will be a critical refraction event such as the event 14. Since the event is the first event in each trace, step 20 may be carried out using an automatic picking method, although it may alternatively be performed manually.

At step 21, a calibration filter is determined that is the best fit to the data in the selected offset range and time window. This is done by calculating the down-going pressure constituent above the seafloor from the pressure and vertical particle velocity recorded at the receiver using equation (2), and finding the calibration filter that minimises the energy in the down-going constituent of the pressure.

At step 22 the filter $a(f)$ is applied to all the desired traces of the vertical component of the seismic data acquired at step 17 or retrieved from storage at step 18.

At step 23 the calibrated vertical component data is then used as input into any process requiring a combination of several seismic components. For example, filters for determining the up-going and down-going constituents of the pressure above the seafloor may be determined, using equation (2) and the calibration filter determined at step 21.

If desired, steps 22 and 23 may be omitted. In this case the calibration filter determined at step 21 may be output for display or stored for subsequent use.

In an alternative embodiment of the invention, a wavenumber-dependent filter is determined by combining the approach of Schalkwijk et al with the present invention. In this embodiment, a calibration filter is determined from critical refraction events occurring at long offsets, as described above with reference to steps 17 to 21 of Figure 10. A second calibration filter is then determined from traces in which it is possible to define a time-offset window that contains only primary reflection events. A calibration filter is determined for these traces in the manner described by Schalkwijk et al. A suitable region of data for obtaining this filter is indicated on Figure 5 as region D.

The calibration filter determined from critical refraction events at long offset and the calibration filter determined from primary reflection events at low offset are then combined to produce a wavenumber-dependent calibration filter. The filters may be combined using an interpolation technique to determine the filter to be applied at a given offset.

In this embodiment, step 22 of Figure 10 is replaced by the step of calibrating the vertical component using the wavenumber-dependent calibration filter. Alternatively steps 22 and 23 may be omitted, and the wavenumber-dependent calibration filter can be output or stored for future use.

An alternative way to obtain a wavenumber-dependent calibration filter is to compute a calibration filter for each separate trace in the offset range selected at step 19. In this alternative embodiment steps 20 and 21 are performed on each trace (or on a plurality of selected traces) in the offset range selected at step 19 so that calibration filters are determined for several different wavenumbers. Alternatively, the traces in the offset range selected at step 19 can be grouped, and a calibration filter can be determined for each group of traces, for example using a least squares method. Again, this results in calibration filters for several different wavenumbers.

Once calibration filters have been obtained for several different wavenumbers, it is possible to interpolate between and/or extrapolate from these calibration filters to obtain a wavenumber-dependent calibration filter This method would, however, only work well for a time-offset window containing only primary reflections (i.e., the window D in Figure 5), since the vertical slowness is constant for the refracted event. The wavenumber-dependent calibration filter may be used immediately, or may be output or stored for future use.

A further alternative method is to define time-offset windows around several refraction events of different vertical slownesses, and determine a plurality of calibration filters (one calibration filter can be obtained from data in each window). A wavenumber-dependent calibration filter can be obtained by interpolation between and/or extrapolation from these calibration filters. If desired, one or more calibration filters determined from a time-offset window containing only primary reflections can also be used in the interpolation and/or extrapolation. The wavenumber-dependent calibration filter again may be used immediately, or may be output or stored for future use.

It will be noted in Figure 5 that the primary reflection event is obscured by other events at long offsets. It will therefore be extremely difficult to compute a reliable calibration filter at long offsets using the method of Schalkwijk et al, owing to the difficulty of determining a time window that contains only primary reflection events. Furthermore, even if a time window that contained only primary reflection events could be determined for the long offset traces in Figure 5, this could only be done by a manual picking method and could not be automated.

The invention has been described above with reference to a calibration filter that calibrates the vertical particle motion with regard to the pressure, on the assumption that the pressure has been accurately recorded. The invention is not limited to this, however, and in principle could be used to determine a calibration filter that calibrates the pressure with regard to the vertical particle motion, on the assumption that the vertical particle motion has been accurately recorded.

Figure 11 is a schematic block diagram of an apparatus 34 according to the present invention. The apparatus is able to carry out a method according to the present invention.

The apparatus 34 comprises a programmable data processor 27 with a program memory 28, for instance in the form of a read only memory ROM, storing a program for controlling the data processor 27 to process seismic data by a method of the invention. The apparatus further comprises non-volatile read/write memory 29 for storing, for example, any data which must be retained in the absence of power supply. A "working" or "scratchpad" memory for the data processor is provided by a random access memory (RAM) 30 An input device 31 is provided, for instance for receiving user commands and data. An output device 32 is provided, for instance for displaying information relating to the progress and result of the method. The output device may be, for example, a printer, a visual display unit or an output memory.

Seismic data for processing may be supplied via the input device 31 or may optionally be provided by a machine-readable store 33.

The program for operating the apparatus and for performing a method as described hereinbefore is stored in the program memory 28, which may be embodied as a semi-conductor memory, for instance of the well-known ROM type. However, the program may be stored in any other suitable storage medium, such as magnetic data carrier 28a (such as a "floppy disc") or CD-ROM 28b.

CLAIMS:

1. A method of processing multi-component seismic data obtained from seismic signals propagating in a medium, the method comprising the steps of: selecting a first portion of the seismic data containing only events arising from critical refraction of seismic energy; and determining a first calibration filter from the first portion of the seismic data, the first calibration filter being to calibrate a first component of the seismic data relative to a second component of the seismic data.

2. A method as claimed in claim 1 wherein the first portion of the seismic data is data acquired with a long source-receiver offset.

3. A method as claimed in claim 1 or 2 wherein the first component is the vertical component of particle motion and the second component is pressure.

4. A method as claimed in claim 1 or 2 wherein the first component is pressure and the second component is the vertical component of particle motion.

5. A method as claimed in claim 1, 2, 3 or 4 wherein the step of determining the first calibration filter comprises minimising the energy immediately above the seafloor of the downgoing constituent of the second component for the selected portion of the seismic data.

6. A method as claimed in any preceding claim and comprising the further steps of selecting a second portion of the seismic data containing only events arising from primary reflection of seismic energy and determining a second calibration filter from the second portion of the seismic data, the second calibration filter being to calibrate the first component of the seismic data relative to the second component of the seismic data.

7. A method as claimed in claim 6 and comprising the further step of determining a wavenumber-dependent calibration filter from the first calibration filter and the second calibration filter.

8. A method of processing multi-component seismic data obtained from seismic signals propagating in a medium, the method comprising the steps of: selecting a first portion of the seismic data in which the first arrival contains only upwardly propagating seismic energy above the seafloor, and determining a first calibration filter from the first portion of the seismic data, the first calibration filter being to calibrate a first component of the seismic data relative to a second component of the seismic data.

9. A method as claimed in any preceding claim and comprising the further step of calibrating the first component of the seismic data using the first calibration filter.

10. A method as claimed in claim 7 and comprising the further step of calibrating the first component of the seismic data using the wavenumber-dependent calibration filter.

11. A method of seismic surveying comprising the steps of: actuating a source of seismic energy; acquiring seismic data at a receiver spatially separated from the source; and processing the seismic data by a method as defined in any of claims 1 to 10.

12. An apparatus for processing multi-component seismic data to determine a calibration filter for calibrating a first component of the seismic data relative to a second component of the seismic data, the apparatus comprising: means for selecting a first portion of the seismic data containing only events arising from critical refraction of seismic energy; and means for determining a first calibration filter from the first portion of the seismic data.

13. An apparatus for processing multi-component seismic data to determine a calibration filter for calibrating a first component of the seismic data relative to a second component of the seismic data, the apparatus comprising: means for selecting a first

portion of the seismic data in which the first arrival contains only upwardly propagating seismic energy above the seafloor; and means for determining a first calibration filter from the first portion of the seismic data.

14. An apparatus as claimed in claim 12 or 13 and further comprising means for calibrating the first component of the seismic data using the first calibration filter.

15. An apparatus as claimed in any of claims 12 to 14 and comprising a programmable data processor.

16. A storage medium containing a program for an apparatus as defined in claim 15.

Remote User

[redacted]

14.0202-GB, 20021030, Search Report.pdf
10/31/07 02:44 PM (4)

The Patent Office COPYRIGHT • TRADE MARKS

INVESTOR IN PEOPLE

WesternGeco Limited
% Marks & Clerk
4220 Nash Court
Oxford Business Park South
OXFORD
OX4 2RU

The Patent Office
Patents Directorate

Concept House
Cardiff Road, Newport
South Wales NP10 8QQ

Examiner: 01633 813792
[†]E-mail: steven.gross@patent.gov.uk
Switchboard: 01633 814000
Fax: 01633 814444
Minicom: 08459 222250
DX 722540/41 Cleppa Park 3
http://www.patent.gov.uk

Your Reference: AMS.P51884GB
Application No: GB 0200560.1

4 October 2002

Dear Sirs

Patents Act 1977: Search Report under Section 17(5)

I enclose two copies of my search report and a copy of the citations.

Patentability

Your invention may not be considered patentable under Section 1(2)(c) of the Patents Act 1977 since it relates to a mathematical method and a computer program. Further consideration will be given at the substantive examination stage, should you wish to proceed with the application.

Publication

I estimate that, provided you have met all formal requirements, preparations for publication of your application will be completed soon after **3 June 2003**. You will then receive a letter informing you of completion and telling you the publication number and date of publication.

[†]**Use of E-mail:** Please note that e-mail should be used for correspondence only.

Amendment/withdrawal

If you wish to file amended claims for inclusion with the published application, or to withdraw the application to prevent publication, you must do so before the preparations for publication are completed. **No reminder will be issued.** If you write to the Office less than 3 weeks before the above completion date, please mark your letter prominently: **"URGENT - PUBLICATION IMMINENT"**.

Yours faithfully

S. Gross

Steven Gross
Examiner

The Patent Office

INVESTOR IN PEOPLE

Application No: GB 0200560.1
Claims searched: 1-20

Examiner: Steven Gross
Date of search: 3 October 2002

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T):

Int Cl (Ed.7): G06F

Other: Online: EPODOC, WPI, PAJ, Internet

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2333364 A	(GECO) See especially page 4 line 31 to page 6 line 20	1, 8, 10, 14, 15, 16 at least
X	EP 0515188 A2	(HALLIBURTON) See especially page 3 lines 6 to 55	1, 8, 10, 14, 15, 16 at least
X	WO 97/29390 A1	(PGS) See whole document	1, 8, 10, 14, 15, 16 at least
X	US 5793702 A	(PAFFENHOLZ) See especially column 3 lines 35 to 55	1, 8, 10, 14, 15, 16 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Remote User

[redacted]

14.0202-GB, 20030619, Notice of Publicat
10/31/07 02:42 PM (3)

The Patent Office

INVESTOR IN PEOPLE

WesternGeco Limited
c/o Marks & Clerk
4220 Nash Court
Oxford Business Park South
OXFORD
OX4 2RU

RECEIVED
18 JUN 2003
MARKS AND CLERK

The Patent Office
Patents Directorate

Concept House
Cardiff Road
Newport
South Wales NP10 8QQ
United Kingdom

Direct line: 08459 500505
Switchboard: 01633 814000
Fax: 01633 814827
Minicom: 08459 222250
DX 722540/41 Cleppa Park 3
http://www.patent.gov.uk

Your Reference: AMS.P51884GB
Our Reference:

17 June 2003

Dear Sir/Madam

PATENTS ACT 1977: PATENTS RULES 1995
NOTICE OF PUBLICATION: APPLICATION NUMBER GB0200560.1

1. Preparations for publication of your patent application are now complete. It will be published on **16 July 2003** with the publication number **GB2384068**.

2. On the publication date, details of your application will be entered in the Register of Patents. From then onwards those details, and the application file, will be open to public inspection at the Patent Office, Concept House, Cardiff Road, Newport, South Wales, NP10 8QQ and at the Patent Office, Harmsworth House, 13-15 Bouverie Street, London, EC4Y 8DP.

3. IMPORTANT: If you want your application considered for grant of a patent, you must, if you have not already done so, ensure that a request for substantive examination on Patents Form 10/77, together with the required fee (currently **£70.00**), is received by the Patent Office within 6 months of the publication date, that is by **16 January 2004**. That period can be extended by one month by sending us Patents Form 52/77, together with the required additional fee (currently £135.00).

4. IMPORTANT: If the request and fee for substantive examination are not received by the Patent Office in time, your application will be treated as withdrawn.

5. The information in paragraph 3 does not apply to substantive examination of either a "divisional" application made under Section 15(4) of the Act, or a patent application made following entitlement proceedings. If you would like further information, or if you would like us to send you a blank Patents Form 10/77 (or Patents Form 52/77), please telephone our enquiry number, 08459 500505.

[PLEASE TURN OVER]

6. You will be sent one free copy of the published application. Further copies may be bought from the Patent Office (Sales), Concept House, Cardiff Road, Newport, South Wales, NP10 8QQ and also, for a limited period from the Patent Office, Harmsworth House, 13-15 Bouverie Street, London EC4Y 8DP. If you want to know the prices of publications, you should telephone sales on 01633 814842. If you order extra copies of your published application, please quote the publication number shown in paragraph 1 above, followed by the suffix "A".

Yours faithfully

Kurt Stephens
Publishing Section

Remote User

[redacted]

14.0202-GB, 20050201, FIRST EXAMINATION
10/26/07 05:11 PM (3)

GA 20/5 R
-> A41

The Patent Office

INVESTOR IN PEOPLE

WesternGeco Limited
c/o Marks & Clerk
4220 Nash Court
Oxford Business Park South
OXFORD
OX4 2RU

The Patent Office
Patents Directorate

Concept House
Cardiff Road, Newport
South Wales, NP10 8QQ

Examiner: 01633 813710
[1]**E-Mail:** jake.collins@patent.gov.uk
Switchboard: 01633 814000
Fax: 01633 814444
Minicom: 08459 222250
DX: 722540/41 Cleppa Park 3
http://www.patent.gov.uk

Your Reference: AMS.P51884GB
Application No: GB0200560.1

20 January 2005

RECEIVED
25 JAN 2005
MARKS AND CLERK

Dear Sirs

Patents Act 1977: Examination Report under Section 18(3)

Latest date for reply: **20 May 2005**

I enclose two copies of my examination report.

By the above date you should either file amendments to meet the objections in the enclosed report or make observations on them. If you do not, the application may be refused.

Yours faithfully

Jake Collins
Examiner

[1]**Use of E-mail:** Please note that e-mail should be used for correspondence only.

Your ref :	AMS.P51884GB	**Examiner :**	Jake Collins
Application No:	GB0200560.1	**Tel :**	01633 813710
Applicant :	WesternGeco Limited	**Date of report :**	20 January 2005
Latest date for reply:	20 May 2005	Page 1/1	

Patents Act 1977
Examination Report under Section 18(3)

Plurality of invention

1. Your claims define two separate inventions not forming a single inventive concept. The inventions are:

a) Methods and apparatus for processing multi-component seismic data as in claims 1-7 and 10-15.
b) Methods and apparatus for processing multi-component seismic data as in claims 8, 9 and 16-20.

You will need to amend your claims, so that they relate to only one invention or inventive concept. You will also need to make consequential amendments to the description. You may wish to consider filing a divisional application. Any such application should normally be filed no later than 3 months before the expiry of the period for putting the present application in order.

Conflict with a corresponding European patent application

2. This application appears to be similar to your European patent application published under number EP 1470436, having the same priority date and designating GB. If patents granted on these two applications relate to the same invention, the Comptroller will in due course revoke the patent granted on the present application unless **either** you amend the present specification to remove the conflict **or**, before the date of grant of the present application under Section 25(1), you begin proceedings to surrender the European patent (UK). Of course if the GB designation is withdrawn before the grant of the European patent, no action will be required under Section 73(2).

Remote User

[redacted]

14.0202–GB, 20050317, Notification of Grant
10/31/07 02:43 PM(3)

The Patent Office

INVESTOR IN PEOPLE

WesternGeco Limited
c/o Marks & Clerk
4220 Nash Court
Oxford Business Park South
OXFORD
OX4 2RU

The Patent Office

Concept House
Cardiff Road
Newport
South Wales NP10 8QQ
http://www.patent.gov.uk

Switchboard:
01633 814000

Direct line 08459 500 505
Our ref
Your ref AMS.P51884GB
Date 15 March 2005

RECEIVED
1 8 MAR 2005
MARKS AND CLERK

Dear Sir/Madam

PATENTS ACT 1977: PATENTS RULES 1995
NOTIFICATION OF GRANT: PATENT SERIAL NUMBER: GB2384068

1. I am pleased to tell you that your patent application number GB0200560.1 complies with the requirements of the Act and Rules, and that you are therefore granted a patent (for the purposes of Sections 1-23 of the Act) as from the date of this letter.

2. Grant of the patent is expected to be announced in the Patents and Designs Journal on 13 April 2005. In accordance with section 25(1), the patent will be treated for all later sections of the Act as having been granted and as taking effect on that date. The patent specification will be published on the same date, and you will receive the Certificate of Grant for your patent and a copy of the specification shortly afterwards.

3. IMPORTANT - It is essential that you take note of the following information about annual renewal payments:

(i) To keep your patent in force, you must pay the Patent Office an annual renewal fee accompanied by Patents Form 12/77 (which can be obtained from this Office).

(ii) For most patents, the first renewal fee is due on the fourth anniversary of the date of filing of the patent application, and each subsequent renewal fee on each subsequent anniversary of the filing date. If you wish, you can pay a renewal fee in the 3-month period before each anniversary.

PLEASE TURN OVER

(iii) In some cases, though, there are special arrangements for the payment of the first renewal fee on a patent. If those special arrangements apply to your patent, you will be given further information when you receive the Certificate of Grant referred to in paragraph 2 above.

(iv) If any renewal fee is not paid by the due date, a further six months is allowed in which to pay the fee. No additional fee is payable if payment is received by the Office during the first month after the due date, but payment received during the second to sixth months after the due date is subject to an additional fee, currently £24 per month or part of a month overdue.

4. If you would like further information about patent renewal fees, or if you would like us to send you a blank Patents Form 12/77, please telephone our Renewals Section on 01633-814655.

5. Copies of the specification of the granted patent will be placed on sale at the Sales Branch, The Patent Office, Cardiff Road, Newport, South Wales NP10 8QQ as from the date in paragraph 2 above and for a limited period at the London Front Office, Harmsworth House, 13-15 Bouverie Street, London, EC4Y 8DP. The copies supplied will have the suffix "B" after the serial number to distinguish the specification of the granted patent from that of the published application.

Yours faithfully

RON MARCHANT
COMPTROLLER GENERAL OF PATENTS,
DESIGNS AND TRADE MARKS

10001 Richmond Avenue
Houston, Texas 77042-4299
Tel: 713-689-5799
Fax: 713-689-1977

WesternGeco

Fax

To:	The Office of the Commissioner for Patents Attention: Magdalen Greenlief	**From:**	Liangang (Mark) Ye
Fax:	571-273-0125	**Fax:**	713-689-1977
Phone:		**Date:**	11/9/2007
Re:	Request for Participation In The Patent Prosecution Highway (PPH) Pilot Program Between the UKIPO and the USPTO	**Pages:**	Fax 1 of 3 – 50 pages Fax 2 of 3 – 46 pages ← ← ← Fax 3 of 3 – 27 pages

☑ **Urgent** ☑ **For Review** ☐ **Please Comment** ☐ **Please Reply** ☐ **Please Recycle**

• **Comments:**

In re Application of: Dirk-Jan van Manen *et al.*	§	Group Art Unit: 2857
Application No.: 10/501,271	§	Confirmation Number: 5653
Filing Date: May 1, 2006	§	Examiner: Unknown
Title of Invention: Method of and Apparatus for Processing Seismic Data	§	Attorney Docket No.: 14.0202-PCT-US

Attached for your consideration is Form PTO/SB/20 – Request for Participation in The Patent Prosecution Highway (PPH) Pilot Program and Petitions to Make the Above-identified Application Special Under the PPH Pilot Program with attachments.

Respectfully submitted,

Liangang (Mark) Ye
Registration Number 48,276
WesternGeco L.L.C.
10001 Richmond Avenue
Houston, Texas 77042
Telephone: 713-689-5799
Facsimile: 713-689-1977

REQUEST FOR PARTICIPATION IN THE PATENT PROSECUTION HIGHWAY (PPH) PILOT PROGRAM BETWEEN THE (1) JPO OR (2) UKIPO, AND THE USPTO

* DUPLICATE 1 *

Application No..	10/501,271	First Named Inventor:	Dirk-Jan van Manen
Filing Date.	May 1, 2006	Attorney Docket No.:	14.0202-PCT-US
Title of the Invention	METHOD OF AND APPARATUS FOR PROCESSING SEISMIC DATA		

THIS REQUEST FOR PARTICIPATION IN THE PPH PILOT PROGRAM MUST BE FAXED TO:
THE OFFICE OF THE COMMISSIONER FOR PATENTS AT 571-273-0125 DIRECTED TO THE ATTENTION OF MAGDALEN GREENLIEF

APPLICANT HEREBY REQUESTS PARTICIPATION IN THE PATENT PROSECUTION HIGHWAY (PPH) PILOT PROGRAM AND PETITIONS TO MAKE THE ABOVE-IDENTIFIED APPLICATION SPECIAL UNDER THE PPH PILOT PROGRAM.

The above-identified application validly claims priority under 35 U.S.C. 119(a) and 37 CFR 1.55 to one or more corresponding JPO application(s) or UKIPO application(s).

The ☐ JPO ☒ UKIPO application number(s) is/are: 0200560 1

The filing date of the ☐ JPO ☒ UKIPO application(s) is/are: 11 Jan. 2002

I. List of Required Documents:

a. **A copy of all JPO office actions (excluding "Decision to Grant a Patent"*) in the above-identified JPO application(s), or a copy of all UKIPO office actions in the above-identified UKIPO application(s).**

☒ Is attached.

☐ Is available via Dossier Access System Applicant hereby requests that the USPTO obtain these documents via the Dossier Access System.

*It is not necessary to submit a copy of the "Decision to Grant a Patent" and an English translation thereof.

b. **A copy of all claims which were determined to be patentable by the JPO in the above-identified JPO application(s), or a copy of all claims which were determined to be patentable by the UKIPO in the above-identified UKIPO application(s).**

☒ Is attached.

☐ Is available via Dossier Access System. Applicant hereby requests that the USPTO obtain these documents via the Dossier Access System.

c. **English translations (where applicable) of the documents in a. and b. above along with a statement that the English translations are accurate are attached.**

Information disclosure statement listing the documents cited in the JPO office actions or UKIPO office actions is attached.

Copies of all documents are attached except for U.S. patents or U.S. patent application publications.

PTO/SB/20 (09-07)
Approved for use through 12/31/2008. OMB 0651-0058
U.S. Patent and Trademark Office; U.S DEPARTMENT OF COMMERCE

REQUEST FOR PARTICIPATION IN THE PATENT PROSECUTION HIGHWAY (PPH) PILOT PROGRAM BETWEEN THE (1) JPO OR (2) UKIPO, AND THE USPTO

(continued)

Application No.:	10/501,271	First Named Inventor.	Dirk-Jan van Manen

II. Claims Correspondence Table:

Claims in US Application	Patentable Claims in JP/UKIPO Application.	Explanation regarding the correspondence
1-7 10-15 17 19-20	1-7 8-13 14 15-16	The corresponding claims are substantively identical except the multiple-dependent claim format in the GB patent

III. All the claims in the US application sufficiently correspond to the patentable/allowable claims in the JPO or UKIPO application.

IV. Payment of Fees:

The Commissioner is hereby authorized to charge the petition fee under 37 CFR 1.17(h) as required by 37 CFR 1.102(d) to [X] Deposit Account No. 50-1720.

☐ Credit Card. Credit Card Payment Form (PTO-2038) is attached.

Signature	/liangang mark ye/	Date	11/09/2007
Name (Print/Typed)	Liangang (Mark) Ye	Registration Number	48,276

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Dirk-Jan van Manen *et al.* §
§
Serial Number: 10/501,271 §
§
Confirmation Number: 5653 §
§
Filing Date: May 1, 2006 §
§
Entitled: METHOD OF AND APPARATUS FOR PROCESSING SEISMIC DATA §
§

Group Art Unit: 2857

Examiner: Unknown

Atty Dkt No.: 14.0202-PCT-US

Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

Second Preliminary Amendment and
Request to Participate in the Patent Prosecution Highway (PPH) Pilot Program between the UKIPO and the USPTO

Dear Sir:

Please amend the application, as indicated, before examination.

No fee is believed to be due in connection with the filing of this preliminary amendment. However, if there are any fees due, the Commissioner is hereby authorized to charge to the Deposit Account 50-1720/14.0202-PCT-US.

Amendment begins on page 2.

Remarks begin on page 4.

Claim listing:

1. (original) A method of processing multi-component seismic data obtained from seismic signals propagating in a medium, the method comprising the steps of: selecting a first portion of the seismic dab containing only events arising from critical refraction of seismic energy; and determining a first calibration filter from the first portion of the seismic data, the first calibration filter being to calibrate a first component of the seismic data relative to a second component of the seismic data.

2. (original) A method as claimed in claim 1 wherein the first portion of the seismic data is data acquired with a long source-receiver offset.

3. (previously amended) A method as claimed in claim 1 wherein the first component is the vertical component of particle motion and the second component is pressure.

4. (previously amended) A method as claimed in claim 1 wherein the first component is pressure and the second component is the vertical component of particle motion.

5. (previously amended) A method as claimed in claim 1wherein the step of determining the first calibration filter comprises minimising the energy immediately above the seafloor of the downgoing constituent of the second component for the selected portion of the seismic data.

6. (previously amended) A method as claimed in claim 1 and comprising the further steps of selecting a second portion of the seismic data containing only events arising from primary reflection of seismic energy and determining a second calibration filter from the second portion of the seismic data, the second calibration filter being to calibrates the first component of the seismic data relative to the second component of the seismic data.

7. (original) A method as claimed in claim 6 and comprising the further step of determining a wavenumber-dependent calibration filter from the first calibration filter and the second calibration filter.

8-9 (currently cancelled)

10. (original) A method of processing multi-component seismic data obtained from seismic signals propagating in a medium, the method comprising the steps of: selecting a first portion of the seismic data in which the first arrival contains only upwardly propagating seismic energy above the seafloor; and determining a first calibration filter from the first portion of the seismic data, the first calibration filter being to calibrate a first component of the seismic data relative to a second component of the seismic data.

11. (previously amended) A method as claimed in claim 1 and comprising the further step of calibrating the first component of the seismic data using the first calibration filter.

12. (previously amended) A method as claimed in claim 7 and comprising the further step of calibrating the first component of the seismic data using the wavenumber-dependent calibration filter.

13. (previously amended) A method of seismic surveying comprising the steps of: actuating a source of seismic energy; acquiring seismic data at a receiver spatially separated from the source; and processing the seismic data by a method as defined in any of claims 1.

14. (original) An apparatus for processing multi-component seismic data to determine a calibration filter for calibrating a first component of the seismic data relative to a second component of the seismic data, the apparatus comprising: means for selecting a first portion of the seismic data containing only events arising Dom critical refraction of seismic energy; and means for determining a first calibration filter from the first portion of the seismic data.

15. (original) An apparatus for processing multi-component seismic data to determine a calibration filter for calibrating a first component of the seismic data relative to a second component of the seismic data, the apparatus comprising: means for selecting a first portion of the seismic data in which the first arrival contains only upwardly propagating seismic energy above the seafloor; and means for determining a first calibration filter from the first portion of the seismic data.

16. (currently cancelled)

17. (previously amended) An apparatus as claimed in claim 14 and further comprising means for calibrating the first component of the seismic data using the first calibration filter.

18. (currently cancelled)

19. (previously amended) An apparatus as claimed in any of claims 14 and comprising a programmable data processor.

20. (original) A storage medium containing a program for an apparatus as defined in claim 19.

Remarks

Claims and amendment

Claims 1-20 were pending.

Claims 8-9, 16, 18 are currently cancelled.

After this amendment, Claims 1-7, 10-15, 17, 19-20 are pending, of which 4 claims (1, 10, 14 and 15) are independent claims and a total of 16 claims are present.

Patent Prosecution Highway (PPH)

It is noted that the pending claims 1-7, 10-15, 17, 19-20 are substantively identical to the claims 1-7, 8-13, 14 and 15-16 respectively in its GB counterpart (except the multiple-dependent-claim format in the GB claims), which is now a UK patent, GB 2 384 068B, issued on 13 April 2005, from an application number 0200560.1, filed on 11 January, 2002. A request for participation in the Patent Prosecution Highway (PPH) Pilot Program between the UKIPO and the USPTO is submitted together with this preliminary amendment.

Applicant believes that the current application is in condition for allowance, and respectfully request that it be allowed.

Respectfully submitted,

/liangang mark ye/

Liangang (Mark) Ye
Registration Number 48,276
WesternGeco, L.L.C.
10001 Richmond Avenue
Houston, Texas 77042
Telephone: (713) 689-5799
Facsimile: (713) 689-1977